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OFF-TARGET FALLOUT OF THE INSECTICIDES FENITROTHION AND AMINOCARB DURING THE SPRUCE BUDWORM SPRAY PROGRAM IN NEW BRUNSWICK 1980 - 1983

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Canada

INLAND WATERS DIRECTORATE
ATLANTIC REGION
WATER QUALITY BRANCH
MONCTON, NEW BRUNSWICK

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ENVIRONMENT CANADA

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A copy will be made available in French upon request.

SOMMAIRE

Entre 1980 et 1983, durant le programme d'arrosage Néo-Brunswickois contre la tordeuse des bourgeons de l'épinette, la Direction de la qualité des eaux, région de l'Atlantique, a effectué des relevés pour suivre les retombées hors-cibles des insecticides fénitrothion et aminocarb appliqués de facon aérienne. L'Aminocarb ne fut pas détecté dans les régions non-visées en 1980, ni en 1983, lorsque cet insecticide se retrouvait dans les protocoles d'arrosage et d'analyse. Quant au fénitrothion, il fut observé dans les régions non-visées durant chacune des quatre années. La plus grande quantité de déposition s'est produite en 1981, lorsque les tronçons d'arrosage furent situés près des sites d'échantillonnage.

En 1980, le fénitrothion fut observé dans des régions non-visées. Un groupe d'observation a indiqué que 60 à 80% de la déposition observée était due à la précipitation humide. Le relevé effectué en 1981 a permis d'établir qu'une quantité allant jusqu'à 0.37 g/ha de fénitrothion fut déposé à la station située dans le parc national de Fundy durant toute la saison, et ceci due à la dérive hors-cibles de l'insecticide. Les études conduites en 1982 et 1983 ont confirmé les dépositions observées en 1980-1981. De plus, elles ont permis de tenter d'identifier une partie de la variabilité spatiale rencontrée durant chacun des relevés. La variabilité du fénitrothion total déposé s'étendait de 0.02 ng/cm^2 à 0.61 ng/cm^2, telle qu'observée dans les collecteurs placés à 2 m

l'un de l'autre.

De 1980 à 1983, les quantités totales de déposition de fénitrothion observées à des stations spécifiques furent calculées. Les valeurs varient entre 0.033 ng/cm^2 en 1982 à 3.8 ng/cm^2 en 1981, au parc national de Fundy.

ABSTRACT

From 1980 to 1983, during the New Brunswick Spruce Budworm Spray Program, the Water Quality Branch, Atlantic Region, carried out surveys to monitor the off-target fallout of the aerially applied insecticides fenitrothion and aminocarb. No aminocarb was detected in the non-target areas in either 1980 or 1983, when it was in the spray and analytical protocols. Fenitrothion was observed in the non-target areas in all four years, with the highest amount of deposition occurring in 1981, when spray blocks were in close proximity to the sampling sites.

In 1980 fenitrothion was observed in non-target areas. One set of observations indicated that between 60 and 80% of the observed deposition was due to wet precipitation. The 1981 survey established that, due to off-target drift, up to 0.37 g/ha of fenitrothion was deposited at the Fundy National Park site during the entire season. The studies of 1982 and 1983 confirmed the observed deposition of 1980-1981 and attempted to identify some of the spatial variability encountered during each survey. The variability of the total deposited fenitrothion ranged from 0.02 ng/cm^2 to 0.61 ng/cm^2, as observed in collectors that were 2 m apart.

From 1980 through to 1983, total amounts of site specific deposition were calculated for fenitrothion. These ranged from 0.033 ng/cm^2 in 1982 to 3.78 ng/cm^2 in 1981 at Fundy National Park.

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INTRODUCTION

Since 1952 large-scale spray programs have been conducted in an attempt to protect New Brunswick forests from the spruce budworm (Choristoneura fumiferana). The use of DDT was phased out during the late 1960's with fenitrothion being used as its replacement, (Pearce et al., 1979).

Armstrong (1973) proposed that very small spray droplets, size range 5-10 micron, can remain airborne for several hours implying that off target drift was possible and that depending on climatic conditions, ground recovery after aerial application could vary from 15% to 75% of the sprayed material.

During the period, 1978-1983, the Water Quality Branch, Atlantic Region, conducted studies into deposition on non-target areas during the annual Spruce Budworm Spraying Program. Pearce, et al. (1979) confirmed that atmospheric transport of fenitrothion was taking place while Pearce and Brun (1980) indicated similar transport of aminocarb (matacil).

With off-target drift having been observed by the aformentioned authors, the 1980 and 1981 studies were undertaken in an attempt to understand the deposition characteristics that would occur with atmospheric drift. In 1980 the objective was to determine the dry fallout to rain washout fraction of the pesticides deposited in non-target areas, while the 1981 program

tried to closely examine rain events to determine when the greatest washout occurred, and also determine the extent of spray drift.

The 1982 and 1983 spruce budworm spray monitoring programs were undertaken with three objectives in mind: firstly, to quantitate the magnitude of deposition, secondly, to verify the deposition dynamics as observed in 1980 and 1981, and lastly, to observe any spatial variability that might occur.

This 1980-1983 report is the final version of work initiated by Bailey et al. (1982,A; 1982,B), and Bailey (1983), wherein, observed off-target drift was reported in ug/L and did not give an adequate description of the deposition of fenitrothion or its rain washout characteristics. The re-interpretation of the data in mass per unit area gives a more satisfactory description of pesticide deposition, on non-target areas.

Though the publication of the observed data may not be timely, it is nonetheless important that the observations made, and problems encountered, be known to researchers investigating off-target fallout.

METHODOLOGY

Pesticide Formulations

During each spray season under consideration, varying amounts of New Brunswick woodlands were sprayed with formulations of either fenitrothion or aminocarb (matacil). The formulations that were most commonly used with fenitrothion utilized either, an emulsifiable fenitrothion concentrate that was dissolved in Dowanol, emulsified with Atlox and diluted with water, or the fenitrothion was dissolved in Cyclosol 63 and diluted with 585 oil. Aminocarb was in a solution with 585 oil using nonylphenol as a surfactant (Eidt, 1982).

In 1980, 1.6 million hectares were treated with aerial insecticides, 1.3 million hectares being treated with fenitrothion and 250,000 ha sprayed with aminocarb. Spraying started on May 24, 1980 and ended on June 20, 1980. (Ketella, 1982).

The 1981 spray program which ran from May 19th to June 20th covered 1.9 million hectares. Fenitrothion was used almost exclusively, except for some small experimental plots. (Ketella, 1982).

During the 1982 spruce budworm spray program, 1.7 million hectares were sprayed, of which 12,000 hectares were experimental plots, 8000 hectares had aminocarb application and 4000 hectares

had commercial Bacillus thuringiensis (Bt) formulations. The remainder was treated with fenitrothion. Spraying started on May 27th and ceased on June 19th. (Ketella, 1982).

Harling (1984) indicated that in 1983, 1.6 million hectares were treated with fenitrothion and 40,000 hectares were treated with either aminocarb or Bacillus thuringiensis. The 1983 fenitrothion formulations were the same as previous years but the matacil formulation changed to a water based emulsion. As in the previous years spraying started in late May (May 24) and ended in late June (June 19) (Henry, 1986).

In each year spray operation were carried out by Forest Protection Limited using TBM-3, DC-6 and Thrush Aircraft. Types of aircraft were dependent on block size and spray formulation (Kettela, 1982).

Sampling Sites

The atmospheric precipitation collectors were located on non target federal lands during all study periods. In 1980, the sampling sites were located at Canadian Forces Base (CFB), St. Margarets, near Chatham and at Fundy National Park at the Wolfe Lake Ranger Station. In 1981 the CFB St. Margarets site was moved to Kouchibouguac National Park at the Information Bureau, and the Fundy Park site was retained at its 1980 location. Sampling sites and graphic representation of the sprayed areas for 1980 and 1981

are indicated on Maps 1, 2 and 3. The NAQUADAT station numbers and sampling description for each site are given in Table 1 (1980) and Table 2 (1981).

Two sampling sites were established in Fundy National Park in 1982, one at the Wolfe Lake Ranger Station and the second at the Administration Building. These sites were approximately 12 km from each other and each site consisted of two bulk rain collectors and one sequential rain collector.

In 1983 the Fundy sites were eliminated and two sampling locations at Kouchibouguac National Park were established. The first site was at the Information Bureau near the Administration Buildings and the second was 100 m away at the Compound Meterological Station.

Table 3 gives the 1982 Fundy National Park sampling sites, their NAQUADAT Station Numbers, the NAQUADAT Parameter Code, and detection limits for fenitrothion. Table 4 provides similar information for the 1983 Kouchibouguac National Park sampling sites.

Maps 4 and 5 illustrate the respective spray blocks for 1982 and 1983 and highlight the sampling locations within each National Park.

Field Apparatus and Collection

Due to the differing purposes of the studies, the field apparatus required to collect precipitation also varied.

In 1980, the precipitation collection apparatus at each site consisted of four cylindrical collectors (Drawing 1) which were located in an open area to avoid contamination from buildings and trees. The units employed heat shielded 15 cm diameter stove pipes made up to lengths of 91 to 107 cm in order to accommodate various funnel systems and XAD-4 resin chromatography columns. The glass funnels (28 cm diameter) rested on top of the pipe, with an Amberlite XAD-4 packed column attached to the funnel using large diameter tygon tubing and gear clamps to secure a water tight connection. The rain water passed through the column and into a glass Winchester.

Four collectors were installed at each site, two, to collect event samples and two for bulk samples. The event collectors were covered until a rain event occurred or was imminent and were re-covered when rain had ended. The bulk collectors were left uncovered to collect dry fallout as well as wet precipitation. Local personnel rinsed each of the bulk funnels with a known amount of glass distilled water daily to wash any dry fallout through the resin column.

The collectors were serviced after rain events of 10 mm or

more, or at a minimum of 7-10 days. The resin columns were replaced and returned to the Moncton Laboratory for elution and regeneration. The volume of water in the winchester was measured and the volume of pre-measured rinse water used was subtracted to determine the actual volume of precipitation passing through the funnel.

The collectors were set up prior to the start of the spray program to collect at least one background set of samples and were left for ten days after spraying was completed to observe when background levels returned.

The 1981, 1982 and 1983 studies required installation of two bulk collectors and one sequential sampler at each of the sites that were established during each study period. The bulk collectors were functionally the same as the 1980 study in that they were designed to collect total rainfall which had passed through an XAD-4 resin column. The funnels were not rinsed as in the previous study. The sequential collectors, (Drawing 2), were designed to segment the precipitation in fractions as determined by volume. The sampler was housed in a plywood cabinet with two 45 cm galvanized steel shallow funnels (with screen mesh to break rain droplets to prevent bouncing from funnel) mounted above the unit. During a rain event, the water proceeded through the funnels into a central 1.3 cm copper tube plugged at the bottom. As the water rose in the central column, it reached the first outlet and flowed towards a 1000 mL widemouth Erlenmeyer flask passing through a 20

cm XAD-4 resin column. When the Erlenmeyer reached the 1000 mL mark, an air lock was formed and the water backed up the outlet to the central tube to the second outlet. The outlets were constructed to prevent accidental flow into an upper outlet before sequencing was completed. The procedure continued until the three flasks were filled or the rain event ended. The dual funnels collected approximately 3000 mL of water during a 10 mm rain event, some of which remained in the tubing of the collector.

The collectors were serviced at least weekly or after a rainfall of 7.5 mm or more. The resin columns were replaced in the bulk collectors as were those in the sequential collectors where water was present in its respective Erlenmeyer flask. The volumes of water in the bulk and sequential collectors were measured, recorded, and the XAD-4 columns returned to the Moncton Laboratory for analysis.

Laboratory Methodology

The sampler resin columns were prepared according to Mallet et al. (1978), whereby, a 250 mm x 21 mm ID chromatography column using a glass wool plug at the bottom, 120 mm of pre-washed Amberlite XAD-4 resin and a second glass wool plug at the top, was rinsed, charged and wrapped in clean aluminum foil for transport to and from the collectors.

Fenitrothion and aminocarb, were co-eluted from the resin columns using ethyl acetate. Fenitrothion was quantitated using packed column, gas liquid chromatography with a flame photometric detector, phosphorus mode, at a detection limit of 0.01 ug/L. Aminocarb was quantitated using reverse phase, high performance liquid chromatography with a fluorescence detector at a detection limit of 0.05 ug/L. Brun (1980) and Brun and MacDonald (1980) detailed the analytical protocol used for both fenitrothion and aminocarb. After elution the columns were regenerated with successive rinsings of acetone, methanol and glass distilled water, were wrapped in clean aluminum foil, and returned to the field.

RESULTS AND DISCUSSION

Rather than interpret the observations based solely on mass per volume of rainfall (ug/L), units of mass per area (ng/cm^2) were used so that temporal variations could be minimized when looking at total deposition of fenitrothion over a sampling season or when examining sequential and bulk data. The calculations of rainfall, and deposition are based upon the area of the collector and the absolute amounts of fenitrothion captured upon the XAD-4 resin columns.

The bulk collectors indicate the total of wet precipitation and dry fallout for a given sampling period while the sum of a bulk collector observations indicates the total deposition for a spray season.

1980 Study

Five positive values, ranging from 0.028 ng/cm^2 to 0.06 ng/cm^2 for fenitrothion were observed during the 1980 spray program. (Tables 5 and 6). The one positive value at St. Margarets was found in the July 2, 1980 sample at a level of 0.060 ng/cm^2 and was determined from 1855 mL of sample. Thirteen days had elapsed from the previous sampling on June 20, 1980. During this period there were nine days with precipitation of amounts varying from trace to 13.6 mm for a total of 44.9 mm of rain. The wind directions were variable during this period and no attempt will be made to

determine which spray block was the origin of the pesticide. The closest spray blocks were 28 km to the south and 38 km to the west.

The four positive values at Fundy National Park were determined during the period of May 30, 1980 - June 6, 1980. Three of the four values ranged from 0.028 - 0.049 ng/cm^2 of fenitrothion. The fourth value was 0.68 ng/cm^2. The order of magnitude difference between the sample "Bulk #2" and the others can only be explained as either a miscalculation, field, or laboratory contamination. There were three rain events during this period ranging from 1.6 to 2.8 mm for a total of 6.4 mm. The deposition values for the bulk and event collectors indicate that between 60% and 80% of the fenitrothion was deposited via wet precipitation and the remainder was deposited via dry fallout.

The wet and dry fallout amounts are based on only the one data set, and represent that period only. More data sets would be needed to more accurately describe the wet to dry ratio. As this segment of the study was not repeated in subsequent years the observed data must be viewed with considerable caution. The wet to dry ratio would be subject to temporal and spatial variability which would have to be eliminated by identical sampling.

The fact that fenitrothion was observed is significant however when considering that the nearest spray blocks were relatively small and were 32 km to the southwest and 50 km to the north.

The absence of any observed aminocarb at either site is no doubt due to the distance, (80 km, from the nearest spray block to the St. Margarets sampling site and 150 km to the Fundy sites), the spray dosage of the formulation, and the detection limit of the analytical methodology. Sampler to spray block distance and size of the spray blocks were all determining factors in the lack of any number of positive responses for either fenitrothion or aminocarb.

1981 Study

A total of 1.9 million hectares were sprayed during the 1981 programs with spray blocks in much closer proximity to the park lands than during 1980. This was reflected in the number of positive observations at the two sites. Twenty-four of the thirty-one samples at Kouchibouguac were positive indicating an event deposition range of 0.082 - 1.13 ng/cm^2. At Fundy Park fifteen of the forty-four samples were positive with an event range of 0.43 - 2.22 ng/cm^2. The data for these sites are presented in Tables 7 and 8.

At Kouchibouguac National Park, the sequential collectors showed positive values in the first column during each of the last eight events (see Column 3, Table 7). An equipment malfunction prior to the servicing on May 22, 1981 resulted in no samples being collected, however, the trace amounts in the bulk sample indicate that a positive value would have been reasonable in the first column. The samples for June 18 are questionable, due to vandalism

of the sampler. However, it should be noted the first sequential column accumulated 0.63 ug in 750 mL of sample.

At Fundy National Park, there were nine positive values from twenty-five samples collected by the sequential collector indicating a deposition range of 0.016 - 0.91 ng/cm^2. All the positive values at Fundy were recorded during the three week period of June 1, 1981 - June 18, 1981, whereas at Kouchibouguac the fenitrothion appeared throughout the study program although lower levels were observed, at the first and last sample dates. Background levels were not adequately determined at Kouchibouguac National Park because the samplers were installed a day after the commencement of spray operations.

The variation between values on the bulk samples is attributed to random particle distribution, local wind conditions, precision of the sampling and analytical methodology. The micro environment around the collectors as created by surrounding woods and buildings as well as the funnels themselves may also have had an effect on the values, an illustrated by the Kouchibouguac bulk values where the samples Bulk #1 are always higher than samples Bulk #2 (Column 6, Table 7).

The large number of positive values in 1981 as compared to 1980 is due to the number of spray blocks and their proximity to the parks. As shown on Map 2, two blocks were actually adjacent to Fundy National Park, one to southwest and the other to the

northeast. A third block was five kilometers west of the monitoring site. A fourth block was twenty-five km west-southwest of the Park. The three blocks closest to the Park totaled approximately 160 km^2, with the fourth block being approximately 70 km^2. Other than these four blocks, the closest spray blocks were 40 km to the north.

At Kouchibouguac, five spray blocks were within a thirty-five km radius of the Park, the closest being six km to the southwest. The five blocks, oriented from southwest to northwest of the Park, totaled approximately 300 km^2. This spray block area would double if a 50 km radius were considered.

Another factor which contributed greatly to the number of positive values was the climate during the 1981 spray period. The weather conditions were described by Forest Protection Ltd. as mediocre. Precipitation was frequent and heavy. It afforded an opportunity to collect a large number of samples with an adequate volume of sample for analysis. At Kouchibouguac from May 22, 1981 - July 7, 1981, there were twenty-four days of precipitation recorded accounting for 172 mm of rain. The daily precipitation exceeded fifteen millimetres on five occasions. The Wolfe Lake weather station at Fundy Park reported eleven days of precipitation totaling 160 mm during June (the period all positive values were found at Fundy). During the same month in 1980, only 71 mm of precipitation was reported.

Though fenitrothion could be present in the atmosphere as either an aerosol or a vapor no attempt to differentiate the source was made, but only to postulate that the fenitrothion would be deposited in the early part of any post-spray rain event. In order to verify this early washout hypothesis the sequential samplers were built to collect the rainfall in 1000 mL increments. The samplers would collect 3000 mL of rain using 3180 cm^2 of collecting surface representing a 9.4 mm rain event before overflow would commence.

Tables 7 and 8 indicate sampler, date of collection, the concentration of fenitrothion in ug/L, the volume of rain collected, and the absolute amount of fenitrothion in ug total on a given XAD-4 column. As well, column 6 indicates the deposition represented by each XAD-4 resin column in ng/cm^2. This calculation was performed so that the bulk amounts could be compared to the sum of the sequential collectors, column 7. The eighth column is the calculation of the amount of fallen precipitation required to produce the amount of collected rainfall. This column indicates when the sequential sampler was in an overflow situation and might not provide accurate data for total deposition.

It was originally intended to utilize the data from the sequential collectors to determine when most of the fenitrothion was washed out of the atmosphere by a rain event. This could not be done because the magnitude of any dry deposition could not be quantitated. In order to properly sequence any rain event a

wet-dry sampler site would have been needed at each sequential site. This problem arose in the 1981 data and was not corrected for any of the subsequent years, which is unfortunate as the sequential collectors would have provided the opportunity to test the hypothesis that fenitrothion would wash out in the early part of a rain event.

The 1981 observations from both Fundy National Park and Kouchibouguac National Park show that the first XAD-4 resin column in each sequential collector had higher deposition than the second or third columns. Unfortunately it is impossible to quantitate the dry fallout to determine how much fenitrothion washed out in the first 3-4 mm of rainfall. The data may still be used to verify the deposition observed with the bulk collectors, to investigate any spatial variability, and to observe the effectiveness of the collector itself.

It was assumed that the bulk samplers should contain an equal or greater mass per area amount of fenitrothion than the sum of the sequential sampler XAD-4 columns. The bulk collectors were assumed to trap 100% of the deposited fenitrothion, and integrate the entire event. One of the problems encountered was the frequent overflow conditions that occurred in the sequential samplers at both sites. If two or more rain events occurred within a short time span, the bulk collector would show a higher amount of fenitrothion than the sequential collector. This is well illustrated by the June 11, 1981 data set from Fundy Park (Table

8). In all likelihood, the sequential sampler functioned properly for the first rain event. But the next 28 mm of rain could not be accommodated by the sequential collector. Yet that same 28 mm of rain could pass through the bulk collector and thus cause the discrepancy in total deposition. The same holds for the June 12, 1981 and June 22, 1981 data from Kouchibouguac National Park.

In order to determine the range of deposited off-target fenitrothion in 1981, the minimum and maximum bulk collector values in ng/cm^2 at each site at a given date were added. For the Kouchibouguac National Park site, 1.67 ng/cm^2 to 3.96 ng/cm^2 was deposited during the entire spray period. While at Fundy National Park, 3.01 ng/cm^2 to 3.78 ng/cm^2 was deposited at the sampling site. These values represent the deposition at the sampling sites only and do not represent deposition in other areas of each National Park. In order to quantitate total deposition to a Park several sites would have been required to determine a deposition gradient.

Kettela (1982) indicated that fenitrothion was applied at a rate of 210 g per hectare or 2100 ng/cm^2. The observed deposition in the non-target area is roughly one thousanth of the application rate and was derived from the analysis of the parent compound only and did not include the two principal breakdown products, fenitro-oxon and s-methyl-fenitrothion. The inclusion of the degradation products would have given a more accurate description of the total of transported pesticide material.

1982 Study

In 1982 there were six positive observations out of fifty-three samples collected, (Tables 9 and 10), at the Fundy National Park sampling locations. This was no doubt due to the lack of spray blocks in close proximity to the Park. Positive observations were obtained for June 18 at both Wolfe Lake and the Administration Buildings. The bulk collectors at Wolfe Lake indicated deposition of 0.078 - 0.098 ng/cm^2 of fenitrothion while the bulk collectors at the Administrative Building showed one at less than detection and the other at 0.033 ng/cm^2. The sequential sampler at Wolfe Lake indicated 0.12 ng/cm^2 while the Administrative site sequential collector contained a total of 0.12 ng/cm^2 of fenitrothion.

When comparing the volumes of rain water collected it is interesting to note that there is good agreement, excluding malfunctions, within each site and when comparing Wolfe Lake to Administration Building site amounts. On June 15 the Administration Building collectors contained significantly more water than did the Wolfe Lake collectors indicating that a localized coastal rain event probably caused the higher volume.

There is a discrepancy in the bulk collector values between the two sites, which, due to the similarity in the volumes, could be attributed to spatial differences in deposition, column mix-up

or perhaps decomposition. Yet while the bulk collectors showed high variability the sequential collectors had very good agreement, 0.12 and 0.12 ng/cm^2.

The distance to the nearest spray blocks, the general absence of spray blocks near Fundy National Park and the relatively dry climatic conditions in June of 1982 accounted for the low number of positive observations as opposed to 1981.

1983 Study

The 1983 observations show that at Kouchibouguac National Park, twenty-nine of the fifty-three XAD-4 resin columns gave positive results for fenitrothion with an event deposition range of 0.033 ng/cm^2 to 0.88 ng/cm^2, (Tables 11 and 12). All of the positive results occurred between May 30, 1983 and June 20, 1983. The administration building site had very low volumes of 20 and 50 mLs and yet recorded deposition of 0.033 ng/cm^2 for June 15, 1983. Because of the minimal rainfall the observed deposition is most likely associated with dry fallout and not precipitation washout.

Table 13 combines the results for both 1983 Kouchibouguac sites showing the volumes of water collected, and the calculated deposition of fenitrothion in ng/cm^2 present on each of the XAD-4 resin columns. The two sampling locations were located 100 m apart and this is reflected by the good agreement between the volumes of water collected in each sampler. The one anomaly among the volume

results is for June 20, 1983 at the Compound Meteorological Station where one bulk collector contained 1700 mL of precipitation while the other had 2150 mL. This was due to a park employee placing a lawn sprinkler too near the sample collector.

Four periods of overflow occurred during the study period, one during the pre-application period, May 26, 1983 and three during the spray period May 30, June 3 and June 20, 1983.

To examine spatial variability, the sum of the positive minimum and maximum bulk amounts for the 1982 spray season were used, and it was found that 0.078 - 0.098 ng/cm^2 of fenitrothion was deposited at Wolfe Lake but that less than 0.01 to 0.033 ng/cm^2 was observed at the Fundy Park Administration Building. This three-fold difference could be due to the fact the Wolfe Lake site was closer to the spray blocks and the administration buildings were 12 km further away from any spray blocks. This could also be an approximate indicator of a west to east deposition gradient.

In 1983 the two Kouchibouguac National Park sampling locations indicated total deposition of 0.75 ng/cm^2 to 1.36 ng/cm^2 at the administration building and 0.15 ng/cm^2 to 0.62 ng/cm^2 at the meteorological station. The volume contained in respective samplers from site to site could vary by up to 10% yet the deposition represented by the sampler could vary by up to 85%. Temporal variability was eliminated by sampling at the same times indicating that the difference in the observations is due mostly to

spatial variability and to a minor extent to analytical methodology variation. The total amounts of fenitrothion deposited were lower in 1982 and 1983 than in 1981, (Table 14). This is related to the high number of spray blocks close to the sampling locations in 1981.

Table 14 also shows that even though the bulk samplers were about 2 m apart at each site there was variability as represented by the range in deposition values. In 1982 when the sample sites were 12 km apart, there was a factor of three between the sites and when the collectors were 100 m apart, 1983, the difference was four to seven times. It must be stressed that the deposition range represents the sum of the minimum and maximum observed values of the bulk collectors for the entire sampling season at a given site. This treatment of the data was used in order to maximize the deposition range to observe the magnitude of spatial variability. On absolute terms very low levels of fenitrothion were deposited on Federal non-target lands. The pair of positive bulk observations for 1980 gave a total deposition of 0.049 and 0.060 ng/cm^2 at Fundy and St. Margarets, while in 1981 five pairs of data gave a range of 1.67 to 2.96 ng/cm^2 at Kouchibouguac National Park and 3 pairs gave a range of 3.01 to 3.78 ng/cm^2 at Fundy National Park.

During 1982 there were few positive observations in Fundy National Park, but from 1 pair of data each from Wolfe Lake and the Administration Building, 0.078 to 0.098 ng/cm^2 and none detected to 0.033 ng/cm^2 were deposited respectively. Many positive

observations were noted in 1983 at the Kouchibouguac National Park sites with 5 pairs of data showing 0.75 to 1.36 ng/cm^2 at the Administration Building while 100 m away at the meterological station, 3 pairs of observations showed 0.15 to 0.62 ng/cm^2 of fenitrothion were deposited. The observed off-target fallout is much lower than the application rate of 2100 ng/cm^2 that was used on the spray blocks.

In terms of deposition range, the agreement between the 1982 sites which were 12 km apart is not good due to the greater distance of one site from the spray blocks. Yet in 1983 when the sites were 100 m apart there was again observed variability. The observations are within the same order of magnitude.

Armstrong (1973) stated that optimal spray conditions occur when the air above the spray blocks is stable with no convective heating. Convective heating causes the air to rise and carry aloft pesticide droplets. If this principle applies at the point of application, then perhaps it can occur at the point of deposition. Any nearby buildings, structures and trees may cause thermal instability and produce the observed variability. The particle size, pesticide formulation, particle distribution, aircraft, wind conditions, terrain, local conditions and analytical methodology can all introduce variability into the data. It is significant however that in years 1980 and 1982 when the spray blocks were few and distant, up to 50 km, that positive observations were noted. This off-target fallout was occurring well beyond the no spray

buffer zones.

Overall the bulk collectors functioned well with only 3 malfunctions during the 4 seasons in operation. This is reflected by the good volume agreement between bulk collectors for similar sampling periods. The sequential samplers were plagued with more malfunctions (9) due to their more complex nature. Because of the frequent overflow conditions (55%) the sequential collectors could not always confirm the deposition levels observed in the bulk collectors. Excluding the overflows they were usually of the same order of magnitude.

SUMMARY AND CONCLUSIONS

In 1980 due to the absence of spray blocks within close proximity to the sampling sites and generally dry climatic conditions, few positive observations of atmospheric drift were obtained. The one positive data set from Fundy National Park indicated that wet precipitation was responsible for approximately 60-80% of pesticide deposition on non-target areas. This observation must have a cautionary note attached, as it is based on only one data set.

During 1981 a total of thirty-nine positive observations for fenitrothion were obtained at the Fundy National Park and Kouchibouguac National Park sites. This was due to the number of spray blocks and their close proximity to the sampling sites. High precipitation levels during the sampling period provided more samples and greater volumes to analyse. Up to 0.38 g/ha of fenitrothion was deposited at the Fundy National Park site during the 1981 Spruce Budworm Spray Program, and up to 0.29 g/ha was deposited at the Kouchibouguac National Park site, as compared to the spray block application rate of 210 g/ha.

The 1982 spray program was primarily in Central and Northern New Brunswick which accounted for the low number (six) of positive observations. The observations from Fundy National Park indicated that between less than detection limit and 0.051 g/ha of fenitrothion was deposited on the park sites in 1982.

The 1983 data indicated a total deposition of 0.015 to 0.11 g/ha at the two Kouchibouguac National Park sites.

All the data from the four years indicated that there existed spatial variability when looking at the absolute amounts of pesticides deposited but that in gross terms the deposition was low.

The 1980 study failed to accurately determine the wet to dry fallout fraction due to the low number of observations. This part of the investigation should have been carried out in 1981-1983, as it negated the ability to interpret any of the sequential data.

RECOMMENDATIONS

The observations gained in 1980 through 1983 in looking at large scale industrial spraying of forest lands confirmed that off-target fallout beyond the buffer zone is a reality and is quantifiable. There are implications to other areas where biocides are used. Long range drift associated with agricultural practices, forestry herbicide use, and power and railway brush control may find its way into the aquatic environment. With the development of more toxic pesticides the magnitude of atmospheric drift may pose a definite risk to non-target organisms beyond no-spray buffer zones.

The most frequent problem encountered during the period 1981-1983 was that of overflow in the sequential collectors. From a total data pool of 43 sets of observations 22 sets, or 55% had overflow conditions. This problem could have been eliminated by attaching an XAD-4 resin column and 4 Litre Winchester to the overflow outlet to obtain a total value from the collector. Also of significance is that recorded malfunctions occurred 11 times representing an 8% failure rate of the collectors and a 25% data set rejection.

The development of samplers that can differentiate between dry particulate fallout and precipitation event washout is imperative to the success of any long range atmospheric transport investigation.

As a result of this re-interpretation of the observations from 1980 to 1983 it is apparent that timely data analysis is important to ensure that any errors or oversights are corrected promptly so as to not impact upon subsequent work.

The authors recommend that the Water Quality Branch continue to investigate off-target fallout, the long range transport of toxic substances, and their deposition in precipitation. The deposition of insecticides, herbicides and fungicides via rainfall and other mechanisms into environmentally sensitive areas needs to be addressed in much the same manner that acid rain has been investigated.

ACKNOWLEDGEMENTS

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R. Howatt of Water Planning and Management must be acknowledged for producing the maps, and preparing the manuscript for publication.

R. Arseneault must also be thanked for preparing the French abstract.

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MAP 1

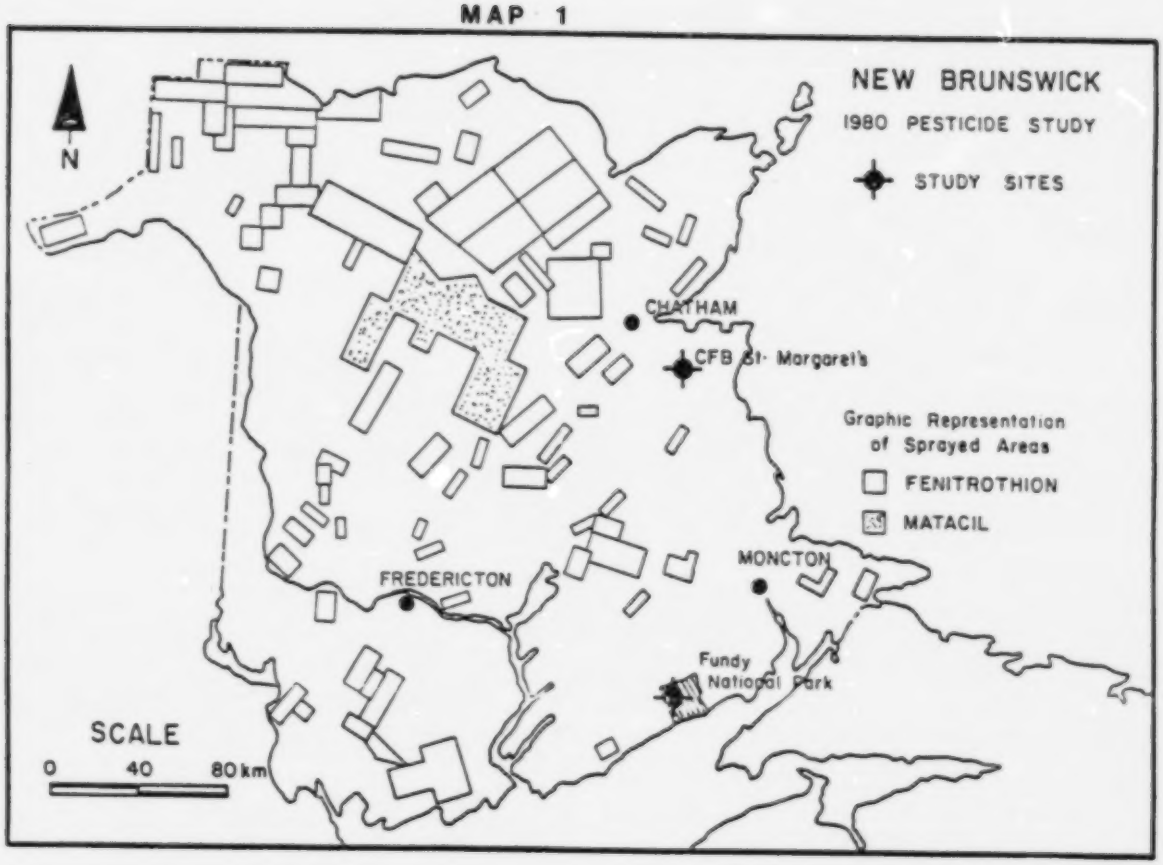


TABLE 1.

1980 SPRUCE BUDWORM SPRAY PROGRAM SAMPLING SITES

==========

CANADIAN FORCES BASE ST. MARGARETS

BULK NO. 1	33NB01BR0001
BULK NO. 2	33NB01BR0002
EVENT NO. 1	33NB01BR0003
EVENT NO. 2	33NB01BR0004

FUNDY NATIONAL PARK AT WOLFE LAKE RANGER STATION

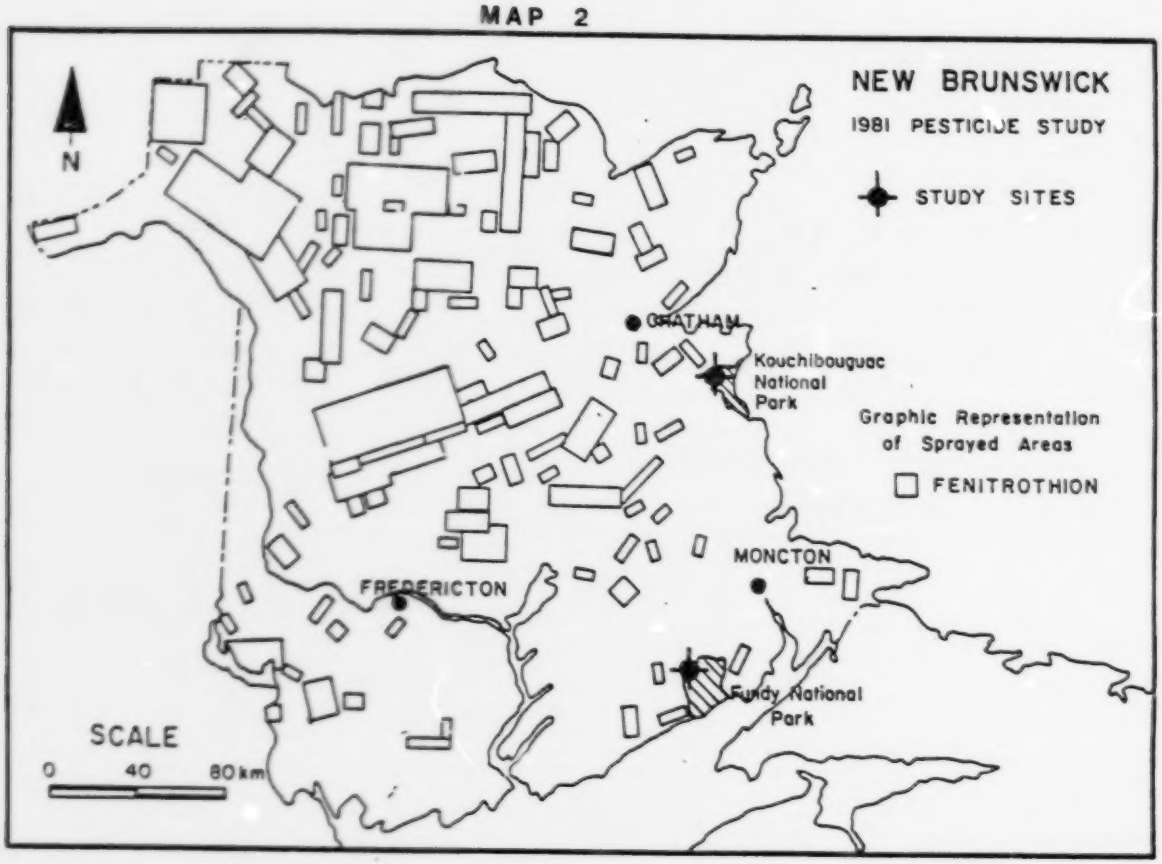
BULK NO. 1	33NB01BV0001
BULK NO. 2	33NB01BV0002
EVENT NO. 1	33NB01BV0003
EVENT NO. 2	33NB01BV0004

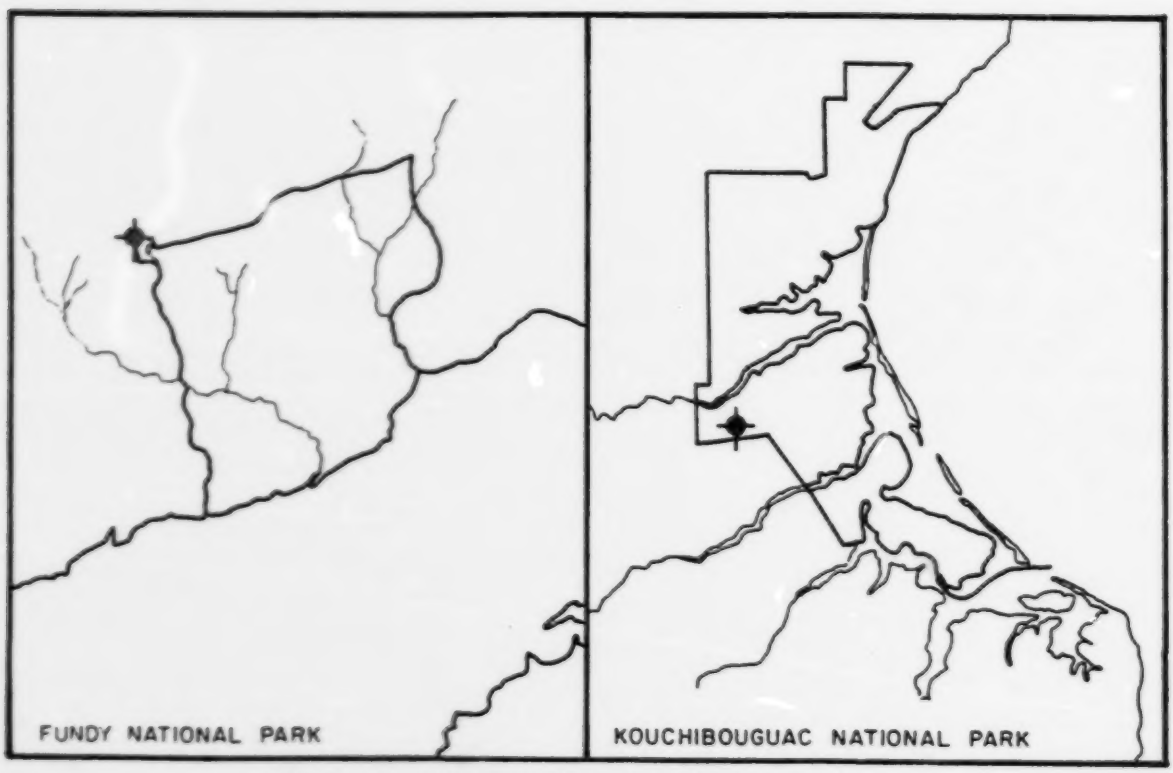
TABLE 2.

1981 SPRUCE BUDWORM SPRAY PROGRAM SAMPLING SITES

KOUCHIBOUGUAC NATIONAL PARK AT INFORMATION BUREAU	
BULK NO. 1	33NB01BR0005
BULK NO. 2	33NB01BR0006
SEQUENTIAL NO. 1	33NB01BR0007
SEQUENTIAL NO. 2	33NB01BR0008
SEQUENTIAL NO. 3	33NB01BR0009
FUNDY NATIONAL PARK AT WOLFE LAKE RANGER STATION	
BULK NO. 1	33NB01BV0001
BULK NO. 2	33NB01BV0002
SEQUENTIAL NO. 1	33NB01BV0005
SEQUENTIAL NO. 2	33NB01BV0006
SEQUENTIAL NO. 3	33NB01BV0007

MAP 2





MAP 3- 1981 PRECIPITATION COLLECTION SITES

TABLE 3.

1982 SAMPLING SITES AT FUNDY NATIONAL PARK

==========

WOLFE LAKE AT RANGER STATION

33NB01BV0001 - BULK #1
33NB01BV0002 - BULK #2
33NB01BV0005 - SEQ #1
33NB01BV0006 - SEQ #2
33NB01BV0007 - SEQ #3

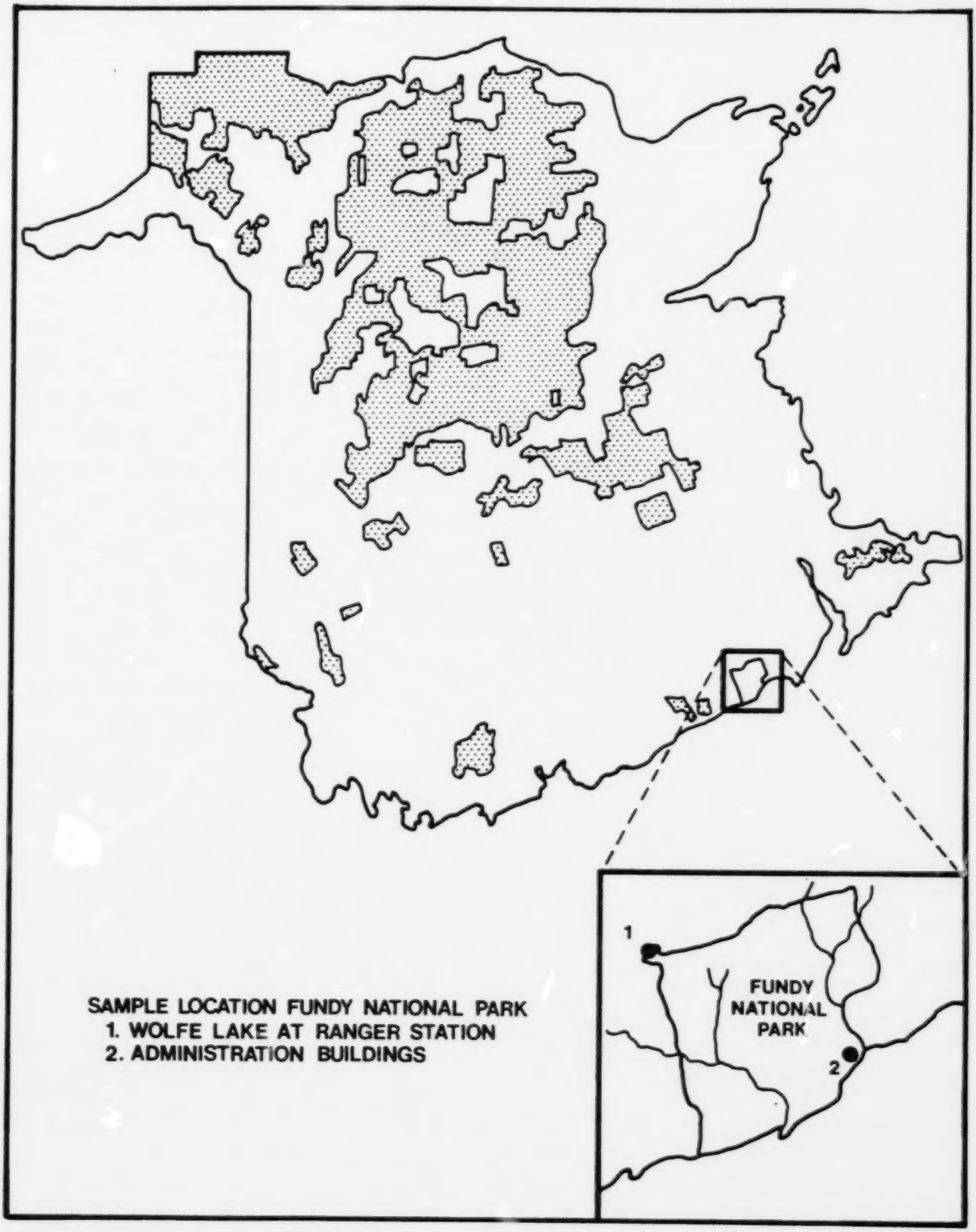
ADMINISTRATION BUILDING

33NB01BV0008 - BULK #1
33NB01BV0009 - BULK #2
33NB01BV0010 - SEQ #1
33NB01BV0011 - SEQ #2
33NB01BV0012 - SEQ #3

==========

PARAMETERS AND DETECTION LIMITS

SAMPLE VOLUME ML. - 97351F
FENITROTHION UG/L - 18331L -- 0.01 UG/L



MAP 4 1982 SPRAY BLOCKS AND SAMPLE LOCATIONS

TABLE 4.

1983 SAMPLING SITES AT KOUCHIBOUGUAC NATIONAL PARK

==========

KOUCHIBOUGUAC INFORMATION BUREAU AT ADMINISTRATION BUILDINGS

33NB01BR0005 - BULK #1
33NB01BR0006 - BULK #2
33NB01BR0007 - SEQ #1
33NB01BR0008 - SEQ #2
33NB01BR0009 - SEQ #3

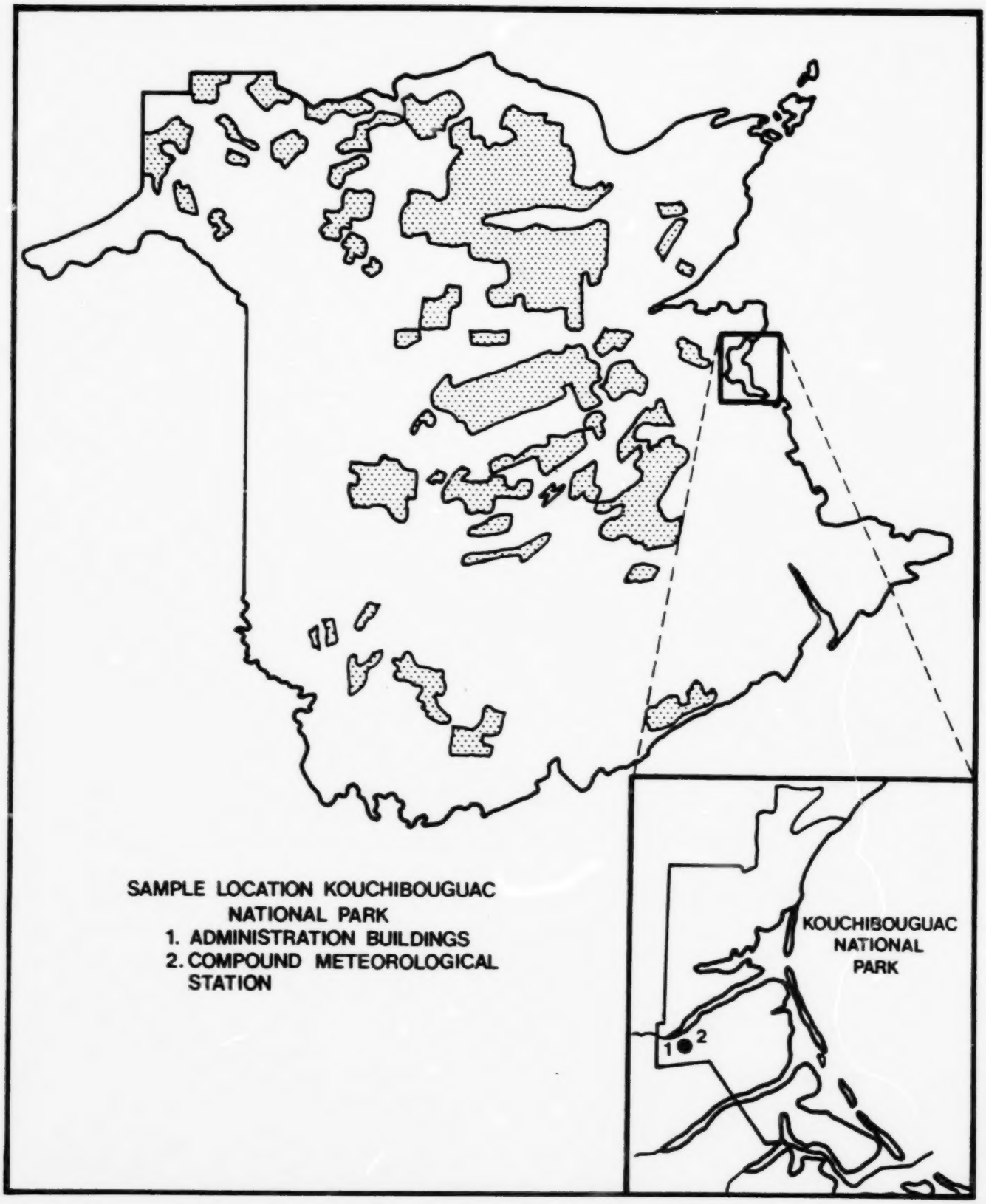
KOUCHIBOUGUAC COMPOUND AT METEROLOGICAL STATION

33NB01BR0010 - BULK #1
33NB01BR0011 - BULK #2
33NB01BR0012 - SEQ #1
33NB01BR0013 - SEQ #2
33NB01BR0014 - SEQ #3

==========

PARAMETERS AND DETECTION LIMITS

SAMPLE VOLUME ML. - 97351F
FENITROTHION UG/L - 18331L -- 0.01 UG/L
AMINOCARB UG/L - 89210L -- 0.05 UG/L



MAP 5 1983 SPRAY BLOCKS AND SAMPLE LOCATIONS

DIAGRAM 1.

BULK AND EVENT TYPE PRECIPITATION COLLECTOR

With XAD-4 Resin Column

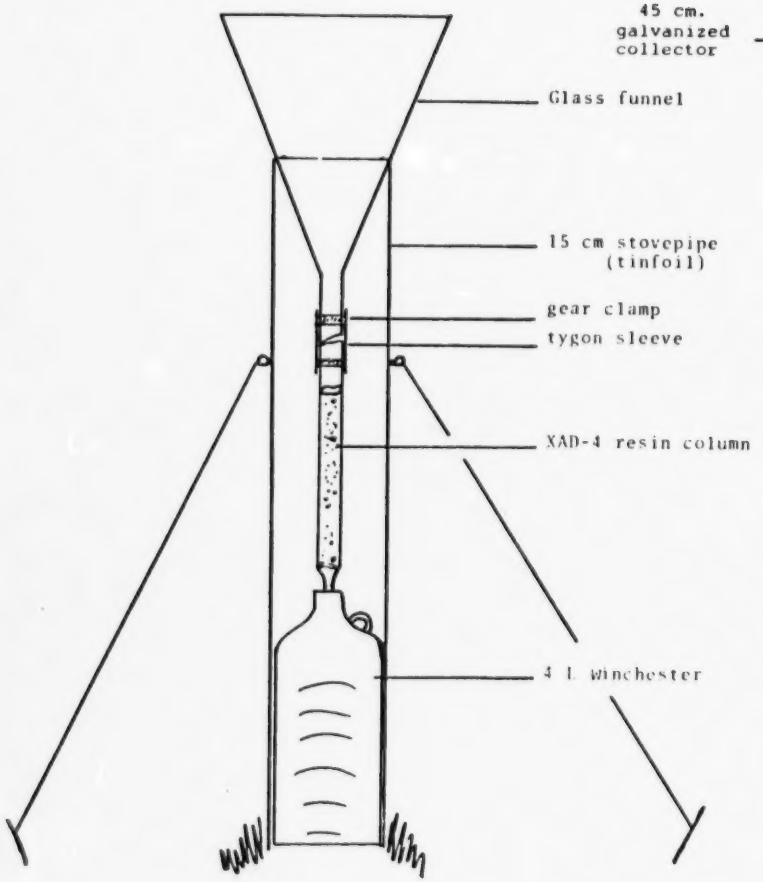


DIAGRAM 2.

SEQUENTIAL PRECIPITATION COLLECTOR

With XAD-4 Resin Column

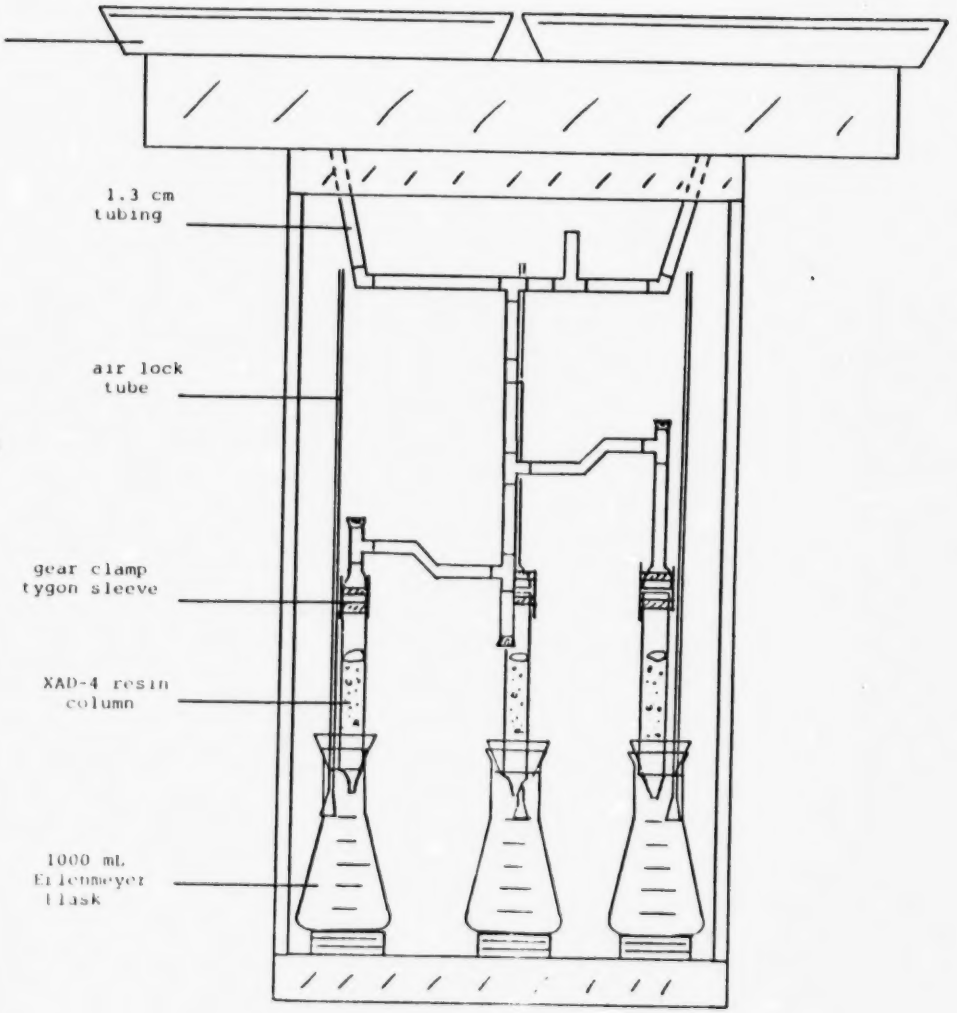


TABLE 5.

1980 SAMPLE RESULTS FOR CANADIAN FORCES BASE ST. MARGARETS

SAMPLER	DATE OF COLLECTION	FENITROTHION UG/L	AMINOCARB UG/L	VOLUME ML	ABSOLUTE UG TOTAL	DEPOSITION NG/CM2
BULK-1	23-MAY-80	L0.01	L0.05	770		
BULK-2	23-MAY-80	L0.01	L0.05	645		
EVENT-1	23-MAY-80	L0.01	L0.05	590		
EVENT-2	23-MAY-80	L0.01	L0.05	560		
BULK-1	02-JUN-80	L0.01	L0.05	180		
BULK-2	02-JUN-80	L0.01	L0.05	240		
EVENT-1	02-JUN-80	L0.01	L0.05	370		
EVENT-2	02-JUN-80	L0.01	L0.05	355		
BULK-1	12-JUN-80	L0.01	L0.05	740		
BULK-2	12-JUN-80	L0.01	L0.05	740		
EVENT-1	12-JUN-80	L0.01	L0.05	960		
EVENT-2	12-JUN-80	L0.01	L0.05	900		
BULK-1	20-LUN-80	L0.01	L0.05	900		
BULK-2	20-JUN-80	L0.01	L0.05	750		
EVENT-1	20-JUN-80	L0.01	L0.05	715		
EVENT-2	20-JUN-80	L0.01	L0.05	730		
BULK-1	02-JUL-80	L0.01	L0.05	2150		
BULK-2	02-JUL-80	0.02	L0.05	1855	0.037	0.060
EVENT-1	02-JUL-80	L0.01	L0.05	1430		
EVENT-2	02-JUL-80	L0.01	L0.05	1465		

NOTES: 14-MAY-80 SAMPLERS INSTALLED AT SITES
24-MAY-80 START OF SPRAY OPERATIONS
20-JUN-80 END OF SPRAY OPERATIONS

TABLE 6.

1980 SAMPLE RESULTS FOR FUNDY NATIONAL PARK

SAMPLER	DATE OF COLLECTION	FENITROTHION UG/L	AMINOCARB UG/L	VOLUME ML	ABSOLUTE UG TOTAL	DEPOSITION NG / CM2
BULK-1	30-MAY-80	L0.01	L0.05	415		
BULK-2	30-MAY-80	L0.01	L0.05	430		
EVENT-1	30-MAY-80	L0.01	L0.05	475		
EVENT-2	30-MAY-80	L0.01	L0.05	645		
BULK-1	06-JUN-80	0.09	L0.05	330	0.030	0.049
BULK-2	06-JUN-80	1.10	L0.05	380	0.418	0.683
EVENT-1	06-JUN-80	0.10	L0.05	165	0.017	0.028
EVENT-2	06-JUN-80	0.08	L0.05	300	0.024	0.039
BULK-1	23-JUN-80	L0.01	L0.05	4050*		
BULK-2	23-JUN-80	L0.01	L0.05	4050*		
EVENT-1	23-JUN-80	L0.01	L0.05	1670		
EVENT-2	23-JUN-80	L0.01	L0.05	3700		
BULK-1	04-JUL-80	L0.01	L0.05	2250		
BULK-2	04-JUL-80	L0.01	L0.05	2215		
EVENT-1	04-JUL-80	L0.01	L0.05	1300		
EVENT-2	04-JUL-80	L0.01	L0.05	1950		

NOTES: * INDICATES OVERFLOW OF BULK COLLECTORS

15-MAY-80 SAMPLERS INSTALLED AT SITE
24-MAY-80 START OF SPRAY OPERATIONS
20-JUN-80 END OF SPRAY OPERATIONS

TABLE 7.
1981 SAMPLE RESULTS FOR KOUCHIBOUGGUAC NATIONAL PARK

SAMPLER	DATE OF COLLECTION	FENITROTHION UG/L	VOLUME ML	ABSOLUTE UG TOTAL	DEPOSITION NG / CM2	SUM SEQ. NG / CM2	CALC. RAIN MM
BULK-1*	22-MAY-81	TRACE	750	—	—		12
BULK-2*	22-MAY-81	TRACE	750	—	—		12
BULK-1	29-MAY-81	L.01	200	—	—		3.2
BULK-2	29-MAY-81	TRACE	200	TRACE	—		3.2
SEQ-1	29-MAY-81	0.20	1000	0.20	0.063		
SEQ-2	29-MAY-81	L.01	110	—	—	0.063	3.4
BULK-1	04-JUN-81	0.26	1750	0.44	0.726		28
BULK-2	04-JUN-81	0.11	1750	0.18	0.294		28
SEQ-1	04-JUN-81	1.00	1000	1.0	0.315		
SEQ-2	04-JUN-81	0.05	1000	0.05	0.016		9.4
SEQ-3	04-JUN-81	0.24	1000	0.24	0.076	0.407	OVER.**
BULK-1*	09-JUN-81	L.01	170	—	—		2.7
SEQ-1*	09-JUN-81	0.04	900	0.04	0.013		
SEQ-2*	09-JUN-81	1.12	170	0.20	0.063	0.076	3.3
BULK-1	12-JUN-81	0.26	2650	0.69	1.128		43
BULK-2	12-JUN-81	0.23	2650	0.61	0.997		43
SEQ-1	12-JUN-81	0.30	1000	0.30	0.094		
SEQ-2	12-JUN-81	0.08	1000	0.08	0.025		9.4
SEQ-3	12-JUN-81	0.06	1000	0.06	0.019	0.138	OVER.
BULK-1*	18-JUN-81	0.50	150	0.08	0.131		2.4
BULK-2*	18-JUN-81	0.16	300	0.05	0.082		4.9
SEQ-1*	18-JUN-81	0.84	750	0.63	0.198	0.198	3.3
BULK-1	22-JUN-81	0.43	1175	0.51	0.833		19
BULK-2	22-JUN-81	0.10	1175	0.12	0.196		19
SEQ-1	22-JUN-81	0.17	1000	0.17	0.054		
SEQ-2	22-JUN-81	0.12	1000	0.12	0.038		9.4
SEQ-3	22-JUN-81	L.01	5	—	—	0.092	OVER
BULK-1	26-JUN-81	0.06	1500	0.09	0.147		24
BULK-2	26-JUN-81	0.04	1500	0.06	0.098		24
SEQ-1	26-JUN-81	0.06	1000	0.06	0.019		
SEQ-2	26-JUN-81	L.01	1000	—	—		9.4
SEQ-3	26-JUN-81	L.01	100	—	—	0.019	OVER
BULK-1	07-JUL-81	TRACE	550	TRACE	—		9.0
BULK-2	07-JUL-81	L.01	550	—	—		9.0
SEQ-1	07-JUL-81	TRACE	1000	TRACE	—		
SEQ-2	07-JUL-81	L.01	1000	—	—		6.0

NOTES: * VANDALISM OR KNOWN MALFUNCTION
** OVERFLOW CONDITION IN SEQUENTIAL COLLECTOR
19-MAY-81 START OF SPRAY OPERATIONS
20-MAY-81 SAMPLERS INSTALLED AT SITE
20-JUN-81 END OF SPRAY OPERATIONS

TABLE 8.

1981 SAMPLE RESULTS FOR FUNDY NATIONAL PARK

SAMPLER	DATE OF COLLECTION	FENITROTHION UG/L	VOLUME ML	ABSOLUTE UG TOTAL	DEPOSITION NG / CM2	SUM SEQ. NG / CM2	CALC. RAIN MM
BULK-1	25-MAY-81	L.01	800	—	—		13
BULK-2	25-MAY-81	L.01	800	—	—		13
SEQ-1	25-MAY-81	L.01	1000	—	—		
SEQ-2	25-MAY-81	L.01	1000	—	—		9.4
SEQ-3 *	25-MAY-81	L.01	650	—	—	—	OVER.**
BULK-1	28-MAY-81	L.01	1100	—	—		18
BULK-2	28-MAY-81	L.01	1100	—	—		18
SEQ-1	28-MAY-81	L.01	1000	—	—		
SEQ-2	28-MAY-81	L.01	1000	—	—		9.4
SEQ-3	28-MAY-81	L.01	1000	—	—	—	OVER.
BULK-1	01-JUN-81	L.01	1000	—	—		16
BULK-2	01-JUN-81	L.01	1000	—	—		16
SEQ-1	01-JUN-81	L.01	1000	—	—		
SEQ-2	01-JUN-81	L.01	1000	—	—		9.4
SEQ-3	01-JUN-81	L.01	1000	—	—	—	OVER.
BULK-1	08-JUN-81	0.89	560	0.50	0.817		9.1
BULK-2	08-JUN-81	1.07	560	0.60	0.980		9.1
SEQ-1	08-JUN-81	2.90	1000	2.90	0.912		
SEQ-2	08-JUN-81	1.46	1000	1.46	0.459		
SEQ-3	08-JUN-81	0.50	900	0.45	0.142	1.513	9.1
BULK-1	11-JUN-81	0.58	2340	1.36	2.222		38
BULK-2	11-JUN-81	0.46	2340	1.08	1.765		38
SEQ-1	11-JUN-81	1.25	1000	1.25	0.393		
SEQ-2	11-JUN-81	0.80	1000	0.80	0.252		9.4
SEQ-3	11-JUN-81	0.12	830	0.10	0.031	0.676	OVER.
BULK-1	18-JUN-81	0.55	640	0.35	0.572		10
BULK-2	18-JUN-81	0.40	650	0.26	0.425		10
SEQ-1	18-JUN-81	1.37	1000	1.37	0.432		
SEQ-2	18-JUN-81	0.07	1000	0.07	0.022		7.8
SEQ-3	18-JUN-81	0.10	500	0.05	0.016	0.470	OVER.

TABLE 8.

1981 SAMPLE RESULTS FOR FUNDY NATIONAL PARK

SAMPLER	DATE	FENITROTHION UG/L	VOLUME ML	ABSOLUTE UG TOTAL	DEPOSITION NG / CM2	SUM SEQ. NG / CM2	CALC. RAIN MM
BULK-1	23-JUN-81	L.01	3300	—	—		54
BULK-2	23-JUN-81	L.01	3300	—	—		54
SEQ-1	23-JUN-81	L.01	1000	—	—		
SEQ-2	23-JUN-81	L.01	1000	—	—		9.4
SEQ-3	23-JUN-81	L.01	1000	—	—	—	OVER.
BULK-1	30-JUN-81	L.01	2960	—	—		48
BULK-2	30-JUN-81	L.01	2965	—	—		48
SEQ-1	30-JUN-81	L.01	1000	—	—		
SEQ-2	30-JUN-81	L.01	1000	—	—		9.4
SEQ-3	30-JUN-81	L.01	1000	—	—	—	OVER.
BULK-1	08-JUL-81	L.01	450	—	—		7.3
BULK-2	08-JUL-81	L.01	450	—	—		7.3
SEQ-1	08-JUL-81	L.01	1000	—	—		
SEQ-2	08-JUL-81	L.01	1000	—	—	—	6.2

NOTES: * INDICATES PRECIPITATION COLLECTOR MALFUNCTIOIN
** OVERFLOW CONDITION IN SEQUENTIAL COLLECTOR
19-MAY-81 START OF SPRAY OPERATIONS
21-MAY-81 SAMPLERS INSTALLED AT SITE
20-JUN-81 END OF SPRAY OPERATIONS

TABLE 9.

1982 SAMPLE RESULTS FOR FUNDY NATIONAL PARK AT WOLFE LAKE

SAMPLER	DATE OF COLLECTION	FENITROTHION UG/L	VOLUME ML	ABSOLUTE UG TOTAL	DEPOSITION NG / CM2	SUM SEQ. NG / CM2	CALC. RAIN MM
BULK #1	26-MAY-82	L.01	950				
BULK #2	26-MAY-82	L.01	975				
SEQ #1	26-MAY-82	L.01	1100				
SEQ #2	26-MAY-82	L.01	1000				
SEQ #3 *	26-MAY-82	L.01	260				
BULK #1	04-JUN-82	L.01	121				
BULK #2	04-JUN-82	L.01	119				
SEQ #1	04-JUN-82	L.01	100				
SEQ #2	04-JUN-82	L.01	100				
BULK #1 *	15-JUN-82	L.01	37				
BULK #2	15-JUN-82	L.01	360				
SEQ #1	15-JUN-82	L.01	1000				
SEQ #2	15-JUN-82	L.01	500				
BULK #1	18-JUN-82	0.15	400	0.060	0.098		6.5
BULK #2	18-JUN-82	0.12	400	0.048	0.078		6.5
SEQ #1	18-JUN-82	0.35	1000	0.35	0.110		
SEQ #2	18-JUN-82	0.06	500	0.030	0.009	0.119	4.7
BULK #1	22-JUN-82	L.01	140				
BULK #2	22-JUN-82	L.01	140				
SEQ #1	22-JUN-82	L.01	100				
SEQ #2	22-JUN-82	L.01	10				
BULK #1	24-JUN-82	L.01	187				
BULK #2	24-JUN-82	L.01	185				
SEQ #1	24-JUN-82	L.01	100				
SEQ #2	24-JUN-82	L.01	100				

NOTES: * INDICATES PRECIPITATION COLLECTOR MALFUNCTION
20-MAY-82 SAMPLERS INSTALLED AT SITE
27-MAY-82 START OF SPRAY OPERATIONS
19-JUN-82 END OF SPRAY OPERATIONS

TABLE 10.

1982 SAMPLE RESULTS FOR FUNDY NATIONAL PARK AT ADMINISTRATION BUILDING

SAMPLER	DATE OF COLLECTION	FENITROTHIOIN UG/L	VOLUME ML	ABSOLUTE UG TOTAL	DEPOSITION NG /CM2	SUM SEQ. NG / CM2	CALC. RAIN MM
BULK #1	26-MAY-82	L.01	990				
BULK #2	26-MAY-82	L.01	990				
SEQ #1	26-MAY-82	L.01	1000				
SEQ #2	26-MAY-82	L.01	1000				
SEQ #3	26-MAY-82	L.01	1000				
BULK #1	04-JUN-82	L.01	120				
BULK #2	04-JUN-82	L.01	115				
SEQ #1	04-JUN-82	L.01	100				
SEQ #2	04-JUN-82	L.01	100				
SEQ #3	04-JUN-82	L.01	100				
BULK #1	15-JUN-82	L.01	785				
BULK #2	15-JUN-82	L.01	770				
SEQ #1	15-JUN-82	L.01	1000				
SEQ #2	15-JUN-82	L.01	1000				
SEQ #3	15-JUN-82	L.01	150				
BULK #1	18-JUN-82	L.01	500	L.01	—		8.1
BULK #2	18-JUN-82	0.04	500	0.02	0.033		8.1
SEQ #1	18-JUN-82	0.37	1000	0.37	0.116		
SEQ #2	18-JUN-82	L.01	1000	L.01	—	0.116	6.
BULK #1	22-JUN-82	L.01	120				
BULK #2	22-JUN-82	L.01	120				
SEQ #1	22-JUN-82	L.01	100				
SEQ #2	22-JUN-82	L.01	100				
BULK #1	24-JUN-82	L.01	201				
BULK #2	24-JUN-82	L.01	201				
SEQ #1	24-JUN-82	L.01	100				
SEQ #2	24-JUN-82	L.01	100				
SEQ #3	24-JUN-82	L.01	30				

NOTES:
20-MAY-82 SAMPLERS INSTALLED AT SITE
27-MAY-82 START OF SPRAY OPERATIONS
19-JUN-82 END OF SPRAY OPERATIONS

TABLE 11.

1983 SAMPLE RESULTS FOR KOUCHIBOUGUAC NATIONAL PARK AT ADMINISTRATION BUILDING

SAMPLER	DATE OF COLLECTION	FENITROTHIION UG/L	AMINOCARB UG/L	VOLUME ML	ABSOLUTE UG TOTAL	DEPOSITION NG / CM2	SUM SEQ. NG / CM2
BULK #1	26-MAY-83	L.01	L.05	1900			
BULK #2	26-MAY-83	L.01	L.05	1900			
SEQ #1 *	26-MAY-83	L.01	L.05	1300			
BULK #1	30-MAY-83	0.08	L.05	950	0.076	0.124	
BULK #2	30-MAY-83	0.08	L.05	950	0.076	0.124	
SEQ #1	30-MAY-83	0.06	L.05	1000	0.06	0.019	
SEQ #2 *	30-MAY-83	L.01	L.05	650	L.01	—	0.019
BULK #1	03-JUN-83	0.02	L.05	2750	0.055	0.090	
BULK #2	03-JUN-83	0.06	L.05	2800	0.168	0.275	
SEQ #1	03-JUN-83	0.66	L.05	1000	0.66	0.208	
SEQ #2	03-JUN-83	0.09	L.05	1000	0.09	0.028	
SEQ #3 *	03-JUN-83	0.09	L.05	450	0.04	0.013	0.249
BULK #1	07-JUN-83	1.60	L.05	340	0.54	0.882	
BULK #2	07-JUN-83	0.91	L.05	340	0.31	0.507	
SEQ #1	07-JUN-83	0.68	L.05	1000	0.68	0.214	
SEQ #2	07-JUN-83	L.01	L.05	75	L.01	—	0.214
BULK #1	15-JUN-83	1.00	L.05	L20.	0.02	0.033	
BULK #2	15-JUN-83	0.40	L.05	L50.	0.02	0.033	
SEQ #1	15-JUN-83	0.60	L.05	300	0.18	0.057	0.057
BULK #1	20-JUN-83	L.01	L.05	1500	L.01	—	
BULK #2	20-JUN-83	0.02	L.05	1400	0.028	0.046	
SEQ #1	20-JUN-83	0.01	L.05	1000	0.01	0.003	
SEQ #2	20-JUN-83	L.01	L.05	1000	L.01	—	
SEQ #3 *	20-JUN-83	L.01	L.05	L100.	L.01	—	0.00
BULK #1	04-JUL-83	L.01	L.05	450			
BULK #2	04-JUL-83	L.01	L.05	450			
SEQ #1	04-JUL-83	L.01	L.05	1000			
SEQ #2	04-JUL-83	L.01	L.05	50			

NOTES: * INDICATES PRECIPITATION COLLECTOR MALFUNCTION
20-MAY-83 SAMPLERS INSTALLED AT SITE
21-MAY-83 START OF SPRAY OPERATIONS
19-JUN-83 END OF SPRAY OPERATIONS

TABLE 12.

1983 SAMPLE RESULTS FOR KOUCHIBOUGUAC NATIONAL PARK AT COMPOUND METEROLOGICAL STATION

SAMPLER	DATE OF COLLECTION	FENITROTHION UG/L	AMINOCARB UG/L	VOLUME ML	ABSOLUTE UG TOTAL	DEPOSITION NG / CM2	SUM SEQ. NG / CM2
BULK #1	26-MAY-83	L.01	L.05	1775			
BULK #2	26-MAY-83	L.01	L.05	1775			
SEQ #1 *	26-MAY-83	L.01	L.05	1300			
BULK #1	30-MAY-83	L.01	L.05	1025			
BULK #2	30-MAY-83	L.01	L.05	1025			
SEQ #1 *	30-MAY-83	L.01	L.05	1000			
BULK #1	03-JUN-83	L.01	L.05	2900	L.01	—	
BULK #2	03-JUN-83	0.09	L.05	2900	0.26	0.425	
SEQ #1	03-JUN-83	0.75	L.05	1000	0.75	0.236	
SEQ #2	03-JUN-83	0.44	L.05	1000	0.44	0.138	
SEQ #3	03-JUN-83	0.24	L.05	1000	0.24	0.076	0.450
BULK #1	07-JUN-83	0.22	L.05	350	0.077	0.126	
BULK #2	07-JUN-83	0.17	L.05	350	0.059	0.096	
SEQ #1	07-JUN-83	0.90	L.05	1000	0.90	0.283	
SEQ #2	07-JUN-83	0.20	L.05	50	0.01	0.003	
SEQ #3	07-JUN-83	0.33	L.05	30	0.01	0.003	0.289
BULK #1	20-JUN-83	0.02	L.05	1700	0.034	0.056	
BULK #2	20-JUN-83	0.02	L.05	2150	0.042	0.069	
SEQ #1	20-JUN-83	0.10	L.05	1000	0.10	0.031	
SEQ #2	20-JUN-83	0.02	L.05	1000	0.02	0.006	
SEQ #3	20-JUN-83	L.01	L.05	1000	L.01	—	0.037
BULK #1	04-JUL-83	L.01	L.05	500			
BULK #2	04-JUL-83	L.01	L.05	500			
SEQ #1	04-JUL-83	L.01	L.05	1000			
SEQ #2	04-JUL-83	L.01	L.05	50			

NOTES: * INDICATES PRECIPITATION COLLECTOR MALFUNCTION
20-MAY-83 SAMPLERS INSTALLED AT SITE
21-MAY-83 START OF SPRAY OPERATIONS
19-JUN-83 END OF SPRAY OPERATIONS

TABLE 13.
COMPARISON OF 1983 KOUCHIBOUGUAC SAMPLE RESULTS

ADMINISTRATION BUILDING				COMPOUND METEROLOGICAL STATION		
VOLUME ML	FENITROTHION DEPOSITION NG / CM2		DATE: SAMPLE: CONDITION:	FENITROTHION DEPOSITION NG / CM2		VOLUME ML
			26-MAY-83			
1900	—		BULK #1	—		1775
1900	—		BULK #2	—		1775
1300	—	*	SEQ #1	—	*	1300
			OVERFLOW			
			30-MAY-83			
950	0.124		BULK #1	—		1025
950	0.124		BULK #2	—		1025
1000	0.019		SEQ #1	—		1000
650	—	*	SEQ #2	NO SAMPLE	*	
			OVERFLOW			
			03-JUN-83			
2750	0.090		BULK #1	—		2900
2800	0.275		BULK #2	0.425		2900
1000	0.206		SEQ #1	0.236		1000
1000	0.028		SEQ #2	0.138		1000
450	0.013	*	SEQ #3	0.076		1000
			OVERFLOW			
			07-JUN-85			
340	0.882		BULK #1	0.126		350
340	0.507		BULK #2	0.096		350
1000	0.214		SEQ #1	0.283		1000
25	—		SEQ #2	0.003		50
NO SAMPLE			SEQ #3	0.003		30
			15-JUN-83			
L20	0.033		BULK #1	NO SAMPLE		
L50	0.033		BULK #2	NO SAMPLE		
300	0.057		SEQ #1	NO SAMPLE		
			20-JUN-83			
1500	—		BULK #1	0.056		1700
1400	0.046		BULK #2	0.069	**	2150
1000	0.003		SEQ #1	0.031		1000
1000	—		SEQ #2	0.006		1000
L100	—	*	SEQ #3	—		1000
			OVERFLOW			
			04-JUL-83			
450	—		BULK #1	—		500
450	—		BULK #2	—		500
1000	—		SEQ #1	—		1000
50	—		SEQ #2	—		50

NOTES: * PRECIPITATION COLLECTOR MALFUNCTION ** LAWN SPRINKLER

TABLE 14.

DEPOSITION AT SAMPLING LOCATIONS 1980 - 1983

YEAR	LOCATION	DATA PAIRS FROM BULK COLLECTORS	RANGE SUM OF MIN AND MAX OF BULK COLLECTORS	DISTANCE BETWEEN BULK SAMPLERS, AND SITES ( )
1980	CANADIAN FORCES BASE ST. MARGARETS	1	N.D. - 0.060 NG/CM2	2 M.
1980	FUNDY NATIONAL PARK AT WOLFE LAKE	0 *	0.049 NG/CM2	2 M.
1981	KOUCHIBOUGUAC NATIONAL PARK, ADMIN. BUILDING	5	1.667 - 2.964 NG/CM2	2 M.
1981	FUNDY NATIONAL PARK AT WOLFE LAKE	3	3.006 - 3.775 NG/CM2	2 M.
1982	FUNDY NATIONAL PARK WOLFE LAKE	1	0.078 - 0.098 NG/CM2	2 M. (12 KM.)
	FUNDY NATIONAL PARK ADMIN. BUILDING	1	N.D. - 0.033 NG/CM2	2 M.
1983	KOUCHIBOUGUAC NATIONAL PARK, ADMIN. BUILDING	5	0.753 - 1.360 NG/CM2	2 M.
	KOUCHIBOUGUAC NATIONAL PARK. COMPOUND MET. STATION	3	0.152 - 0.619 NG/CM2	(100 M.) 2 M.

NOTES: N.D. INDICATES NONE DETECTED IN ONE BULK COLLECTOR
* ONLY ONE BULK SAMPLE VALUE